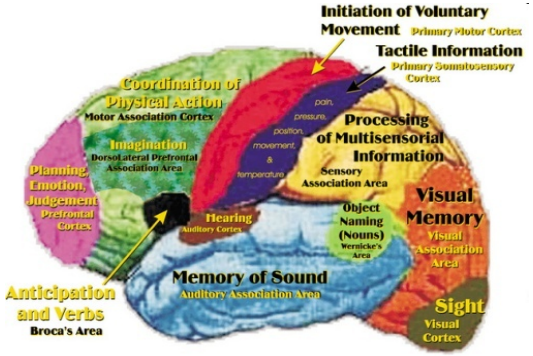
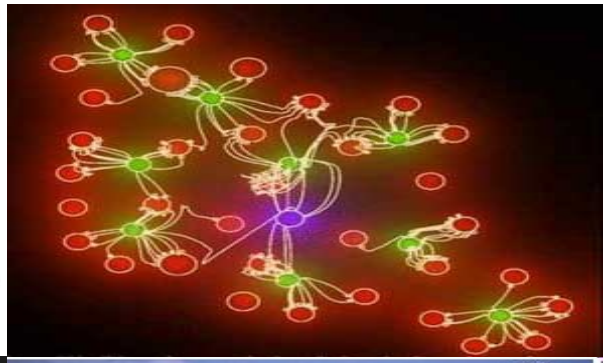
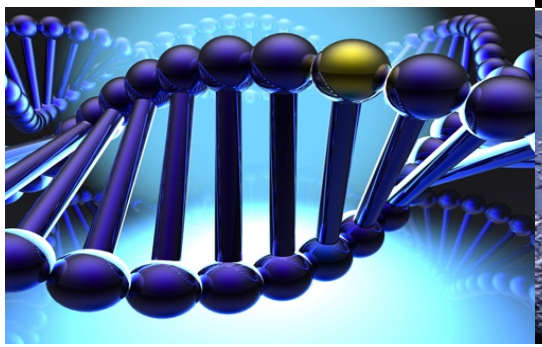
Dr. Xiao-Hua (Helen) Yu

- Professor, Dept. of Electrical Engineering
- Research Interest
  - Computational Intelligence and Its Applications
  - Digital Signal Processing
  - Adaptive control
- Graduate courses taught at Cal Poly
  - EE 509: Computational Intelligence
  - EE 515: Discrete-time Filters
  - EE 513: Modern Control Theory
  - EE 514: Advanced Topics in Control Systems
  - EE 528: Digital Image Processing

Computational Intelligence

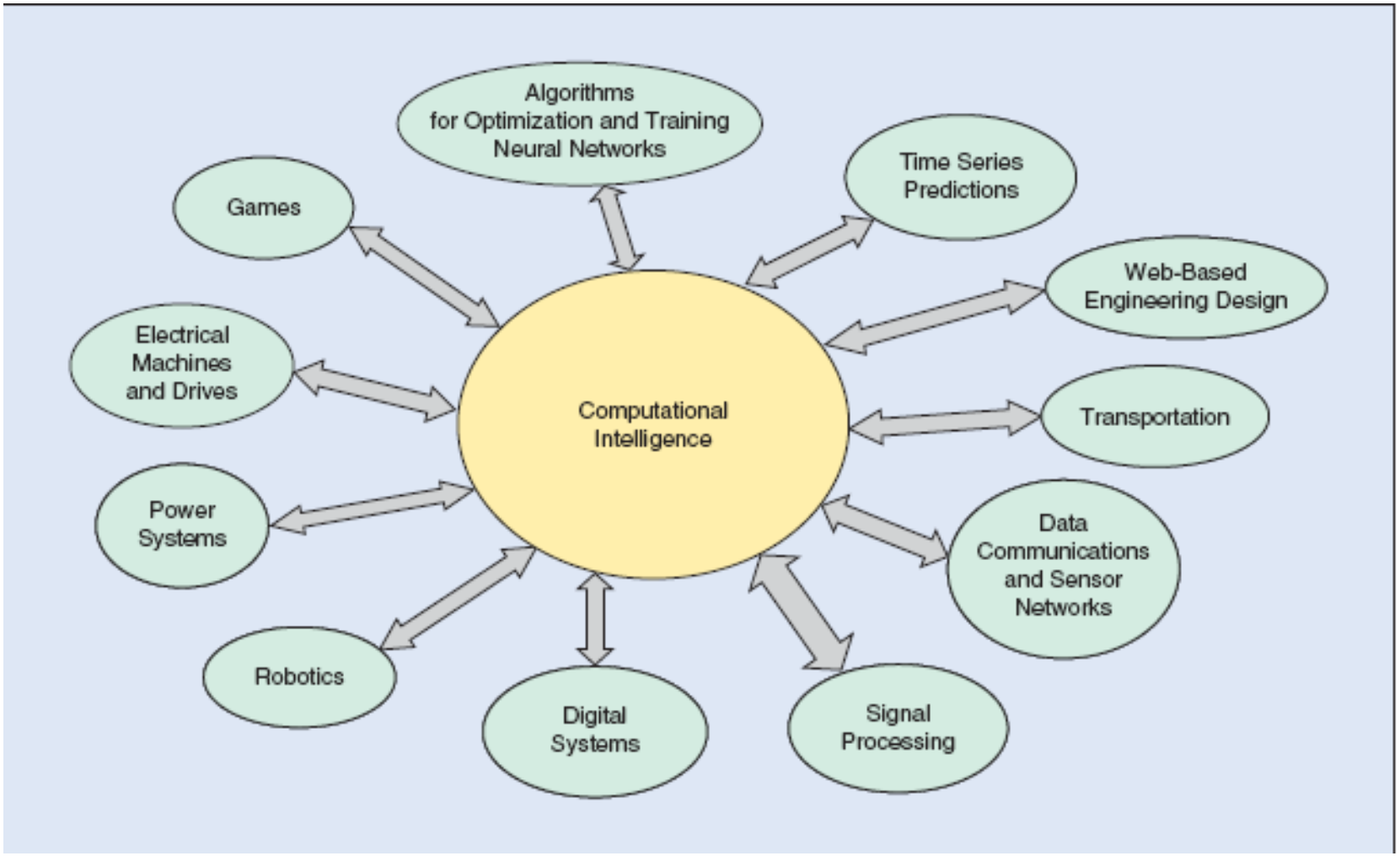






- Areas of study
  - Artificial neural networks
  - Evolutionary computation
  - Swarm intelligence
  - Immuno-computation
- Applications
  - System identification
  - Adaptive control
  - Signal processing
  - Optimization
  - And many more…

Computational Intelligence Applications

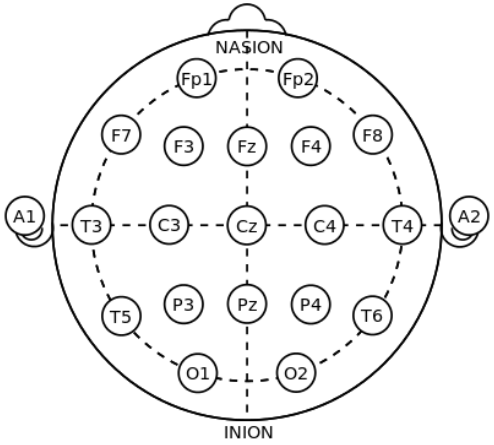


Current Projects

- Biomed signal/image processing, medical diagnosis, and biometrics identification with deep learning and various intelligent paradigms
  - ECG and EEG signals
  - Medical image registration
  - Alzheimer's disease detection
- Smart power grid
  - Electricity price prediction
  - Fault detection and classification
- Control system applications
  - Robot path planning
  - Decentralized multi-robot formation control
  - Reinforcement learning for controller design
- Other AI related applications…

Motor Imagery Classification

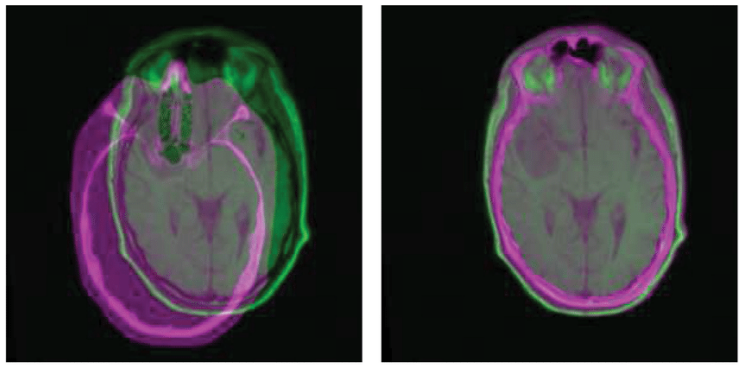
- Electroencephalography (EEG) is commonly used to study brain cortical electrophysiology
  - It is reported that approximately 20 million people in the United States suffer from irreversible nerve damage
  - Neuroprosthetic devices with Brain Computer Interface (BCI) have become a viable solution for paralysis patients in recent years
    - With EEG signal analysis, these systems can interpret (translate) human brain activities into commands to control artificial limbs or robot arms for patients



- Various approaches based on computational intelligence will be studied

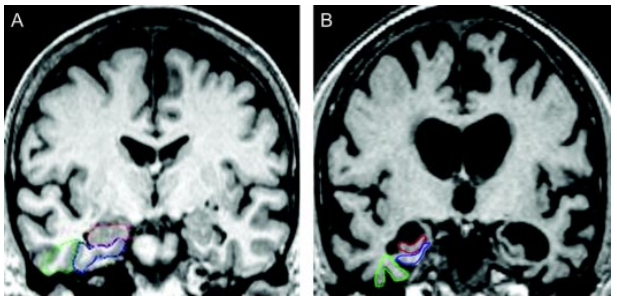
Image Registration

- In clinic studies, multiple images for a patient are usually acquired at different time to allow doctors to monitor the effects of treatment over time
- However, it is usually difficult to have the region of interest (e.g. a tumor) positioned in exactly the same spot or orientation for multiple images
- Image registration transforms different sets of data into one coordinate system in order to align up and overlay multiple images
- Our approach considers both image and frequency domain features



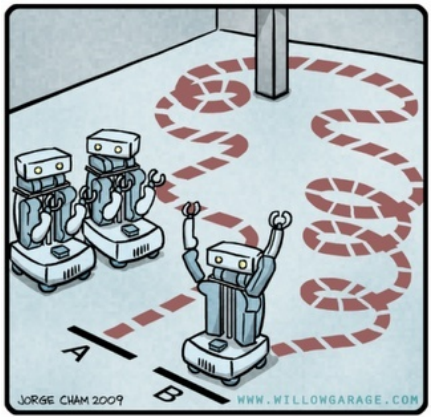
Alzheimer's Disease Detection

- Alzheimer's disease is a chronic neurodegenerative disease that results in progressive cognitive decline and eventually leads to dementia
  - It is the 6th leading cause of death in US. Early detection is crucial for symptom management and treatment
- Brain scan images (CT, MRI, PET, etc.) are often used to detect Alzheimer's disease
  - Electroencephalogram (EEG) can also be used to detect abnormal brain-wave activity
- Artificial neural networks (ANN) and deep learning provide an intelligent way for analysis



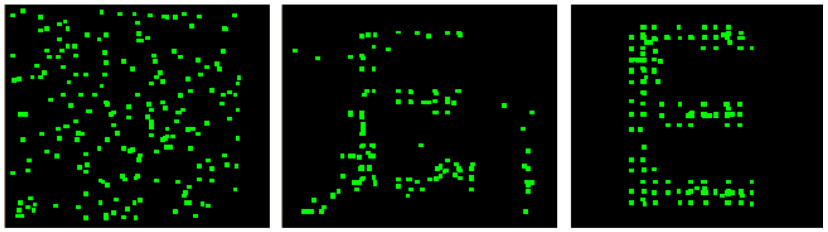
Robot Path Planning

- Advanced Optimization Algorithm for Robot Path Planning
  - Path planning is an essential task for the navigation and motion control of autonomous robot manipulators
  - A difficult task especially in the situation that the optimal path needs to be rerouted in real-time when a new obstacle appears
  - Biologically inspired methods such as swarm intelligence and advanced search algorithms can be applied to find the best route for autonomous robots in a dynamic environment

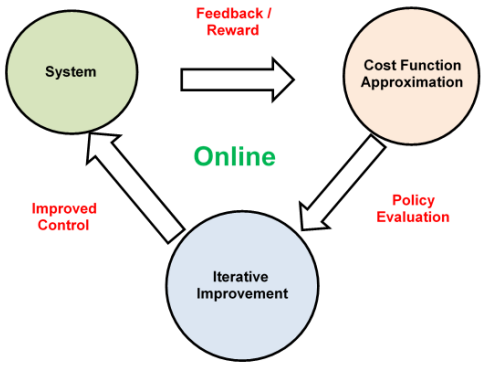


Control Systems Applications

- Collective movement for multi-robots
  - Decentralized multi-robot formation control
  - Social robots
- System Identification
  - A “non-parametric” approach with no or less a priori knowledge of the system dynamics

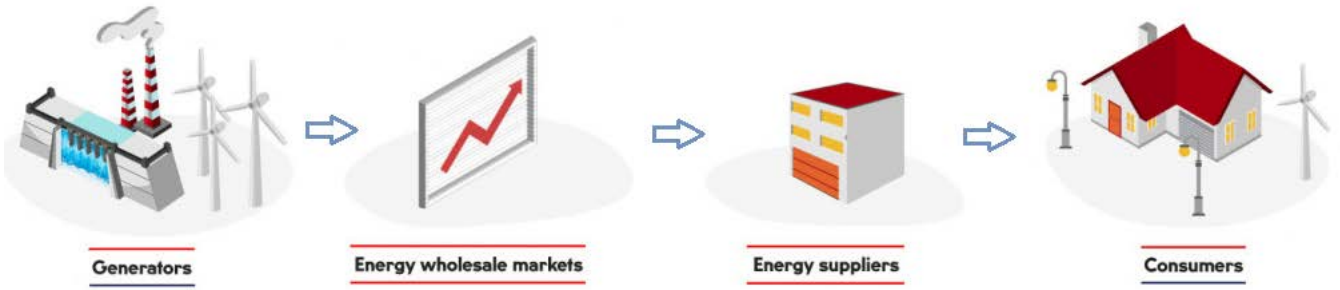


- Reinforcement learning
  - Inspired by natural learning mechanisms, where animals adjust their actions based on reward and punishment stimuli received (the “cause-and- effect” relationship)
  - A system that can improve its performance based on the results of previous actions



Electricity Price Prediction

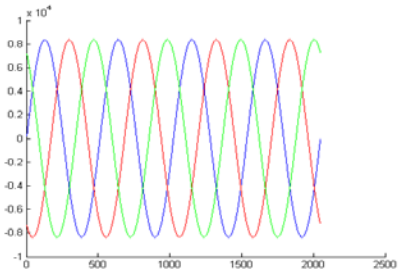
- In electricity market, electricity is a commodity that can be bought, sold, and traded
  - Electricity is, by its nature, usually difficult to store and has to be available on demand
  - Power system stability requires a constant balance between production and consumption
  - Electricity demand depends on many factors such as weather conditions, daily activities (e.g. peak-hours), etc.
  - The goal is to develop an intelligent model to predict electricity price



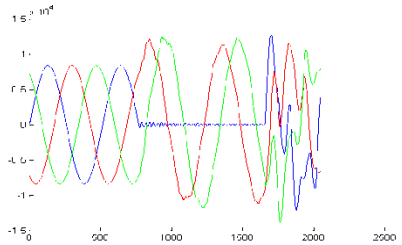
Power System Fault Detection & Classification

- Monitoring the performance of power network automatically is an important component of modern “smart grid”

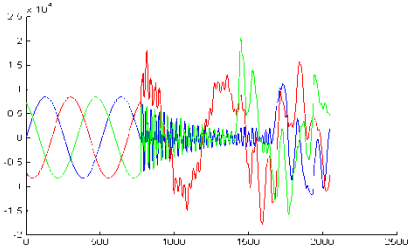
  - A single fault, even when lasting only for a fraction of a second, may affect potentially millions of customers on the grid and result in huge losses and manufacturing downtime in industry
  - These power quality events (PQEs) can be caused by natural disasters, equipment failures, or human errors



No fault



Fault #1



Fault #2

Need More Information?

- Contact Dr. Yu for more project information

  xhyu@calpoly.edu
- Some programming skills are preferred (any language is OK)
- Other projects may also be available upon request and discussion. You are also welcome to propose your own ideas